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COKE QUENCH TOWER PAPER

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## COKE QUENCH TOWER PAPER

### SUMMARY

This paper provides emissions data relative to Ohio SIP TSP rulemaking concerning Rule OAC 3745-17-11(E) for coke quenching. The proposed rule would require Ohio coke plants to equip quench towers with an interior baffle system which is designed and maintained in accordance with good engineering practices. The existing SIP requires Ohio quench towers to meet a process weight based particulate mass emissions limit.

Coke quench towers are circular or rectangular structures used to draft the steam plume and resulting emissions away from the immediate area of the tower. Incandescent coke from a coke oven is pushed into a rail car which travels to the quench tower where water is applied to cool the coke sufficiently to permit the subsequent processing of the coke and to prevent the coke from being further oxidized. Typically, about 12 tons of coke are quenched in 90 seconds with 6-9,000 gallons of water. The cycle is repeated every 10 or 15 minutes after another oven is pushed. Quench towers emit water vapor, steam, water droplets, heated air and particulate and other matter. The latter are emitted as breeze or coarse "grit" (undersized, unagglomerated coke particles), and as fine salts.

Particulate emissions are generated by the fracture of the coke material, and by the emission of salts dissolved in both fine and coarse water droplets created by the quenching process. Particulate testing of quench towers has been conducted at towers in California (1), Texas (1), Indiana (2), New York (2), Ohio (1), Hamilton, Ontario (2), and in Pennsylvania (1). Quench towers present difficult sampling problems due to their high moisture contents, short quenching durations, non-linear flows, and difficult and dangerous physical access. Quench tower emissions have been measured by methods which adequately reduce the effects of many of these problems in only a portion of these tests. Uniform testing and sample recovery procedures, careful definition of process conditions (i.e., baffle and tower design, spray method, coke greenness, water quality), the use of continuous flow rate instrumentation and the use of cyclone precutters to catch much of the problem water droplets and large particulates are important aspects of an adequate quench tower test.

X  
Tests at U.S. Steel, Lorain, Ohio (1975), U.S. Steel, Gary, Indiana No. 3 (1979), U.S. Steel, Gary, Indiana No. 3<sup>S</sup> (1979), Dominion Foundry and Steel, Co. Ltd. (DOFASCO) (1977 and 1981) were conducted using similar and adequate methodology however process conditions vary between sites. These tests provide the data base for the analysis presented here.

The results of the relevant tests to date are as follows:

<u>Test</u>	<u>TDS Level Quench Water (mg/l)</u>	<u>Front Half Emission Rates lb/ton Coal</u>
USSC/Lorain-'76	1050	1.46
	9850	2.73
DOFASCO '77	400	0.27
USSC/Gary No. 3 No. 5	446	0.33
	1588	0.43
	466	0.32
	1404	0.64
DOFASCO '81 Inlet Outlet Outlet Inlet Outlet		
		1.19
	510	
		0.34
	2270	0.48
		5.32
	8850	1.39

NO test  
data between  
2300 and 8800

All of these tests indicate that (1) quench water quality has a significant effect on air emissions, and (2) that a linear relationship exists between air emissions and TDS in the quench water. Significant particulate control can be accomplished by utilizing one of several baffle designs, (e.g., multidirectional, CarlStill "A" Frame,\* etc.). The towers tested met the following minimum specifications:

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\*With off-set tower design.

*check all tests meet this?*

- Baffles must cover 95 percent of tower's cross-sectional area
- Baffle should be placed in the upper two-thirds of the tower
- A spray system should be used to remove particulate buildup
- Inspection of the baffles and cleaning system should be conducted monthly.

Statistical analysis of the air emissions and TDS related values has been conducted and plots for each of the towers tested has been prepared. In some cases the plots have been combined based on similarities between towers. Present and potential emission rates from quench towers in Ohio which use quench water composed of flushing liquor and do not use "clean water quenching", (i.e., 1,500 mg/l TDS) are shown in Table 1. These emissions rates were developed using the following alternatives: (1) status quo, no change, (2) requiring no water quality change but requiring multi-row baffles, (3) requiring water quality of 1500 mg/l and multi-row baffles.

TABLE 1. QUENCH TOWER EMISSION RATES

Plant	TPY Status quo (present)	TPY if: Install multidirectional baffles	TPY if: Improve quench water 1500 mg/l TDS	TPY Install multi- directional baffles quench water 1500 mg/l TDS
Jones & Laughlin	1500	1500	480	480
RSC/Youngstown	1740	860	340	250
RSC/Warren	1440	710	280	210
USSC/Lorain	2385	1630	1400	600
TOTALS	7065	4700	2500	1570
% Reduction	—	33%	65%	78%

## COKE PLANT QUENCH TOWER PAPER

### I. PURPOSE

This paper provides information concerning coke plant quench tower air emission rates, methods of control, and applicability to specific locations in Ohio. These data are developed to assist U.S. EPA and Ohio EPA in understanding the impact of regulating quench tower emissions.

These issues relate to the Total Suspended Particulate (TSP) plan for Ohio. Other quench tower emissions which also occur are not the subject of this paper. Ohio has adopted and submitted to U.S. EPA a proposed SIP revision, which would replace the existing Federal SIP process weight mass emission limit with an obligation to install an interior baffle system which is designed and maintained in accordance with good engineering practices. The rulemaking is in the "proposed notice of rulemaking" stage. Ohio EPA seeks data on costs and emission rates from various quenching control methods. In a letter to U.S. EPA dated January 5, 1982, the Director of the Ohio agency stated:

"With respect to coke quench towers, we understand that the U.S. EPA will be disapproving paragraph (b)(4) of OAC rule 3745-17-11 primarily because it does not require the use of "clean water" (approximately 1500 mg/l TDS) for quenching. U.S. EPA believes that the definition of RACT in Ohio for coke quench towers must address the quality of the quench water.

The U.S. EPA will provide technical information to the Ohio EPA to support the recommended RACT definition for coke quench towers. If upon review of that data the Ohio EPA determines that the U.S. EPA position is both technically and economically defensible, the Ohio EPA will proceed to revise paragraph (B)(4) to reflect the U.S. EPA's definition of RACT."

This paper is intended to provide these data.

## II. BACKGROUND INFORMATION

### A. PHYSICAL ASPECTS OF QUENCHING

Coke quenching is a process used to cool incandescent coke which has just emerged from a coke oven at a temperature of approximately 2000°F to below the ignition temperature of carbon in air (about 1200°F). Quenching normally cools the coke to about 200-400°F. Currently, almost all coke batteries in the United States quench coke with large amounts of water sprayed in a wet quench tower. Quench towers are either circular or rectangular structures and consist of two basic components: the quench tower itself and the water sump as shown in Figure 1.

After the coke is pushed from the oven, it is carried by quench car to the tower. About 15 to 30 seconds after the car enters the tower, the spray system, generally located a few feet above the top of the quench car, is started. Water spraying lasts 2 to 3 minutes and may be continuous throughout the quench or intermittent with alternating periods of 30 seconds to 1 minute of water on/water off. Quench towers emit water vapor, steam, droplets, heated air, particulates and other materials. Particulates are emitted as breeze (undersized, unagglomerated coke particles), as coarse "grit," and as fine salts. The estimated causes of such emissions are:

1. The fracture of the coke material into a powder which is carried up the tower in the heated rush of water, steam, and air.
2. The emission of dissolved salts in both fine and coarse water droplets created by the quenching process.

After the quench is completed, the quench car leaves the tower and moves along the track to the coke wharf.

Water for the quenching operation is stored in the sump. The water is pumped from the sump to the holding tank located on a platform on the tower. It then flows from the tank to the sprayers by gravity. As the water is sprayed on the coke, some is lost to the atmosphere through evaporation and droplet entrainment. The remainder of the water drains back to the sump.

Water is added to the sump as necessary to replace the loss. This makeup water may consist of fresh water from a river or lake or process effluent from other parts of the plant, such as the byproducts plant, the blast furnace, or the coke plant.

Figure 1 also presents a water mass balance for the quench tower. As shown in the diagram, about 380 to 760 gallons of water per ton of coke is sprayed on the coke. Depending on the baffle configuration and spray method, 15 to 40 percent is lost to the atmosphere. Most of the remaining water runs off the coke and back to the sump through a return ditch (sump return). Small amounts are carried out with the coke and lost to the environment through runoff and are lost through evaporation from the sump and spray header tank.

The reader should note the distinction between makeup water and quench water. In past studies, both of these streams have been used to relate water quality to particulate emissions, and each has its particular advantage. In this paper, all relationships between water quality and particulate emissions are based on quench water. This approach is based on the following two observations: (1) particulate emissions are more directly related to quench water quality; and (2) quench water quality can typically be more easily monitored than makeup water quality.

#### B. SOURCES OF QUENCHING MAKEUP WATER

Sources of makeup water to the quench tower include effluent streams from the byproducts plant, blowdown from larry car or pushing scrubber systems, other plant cooling waters, and local surface or ground waters. Figure 2 shows waste streams from a typical byproduct plant. Typical volumetric flow rates and contaminant levels for these waste streams are shown in Table 2.

The flushing liquor used in the collector mains to cool the "foul gas" produced during the coal carbonization process also serves as the carrying medium, to the byproducts plant, for those products condensed during this cooling step. These condensed materials contain ammonia (existing in both the water, weak liquor, and gas that form part of the volatile products formed during carbonization) in two forms classified as "free" and "fixed."

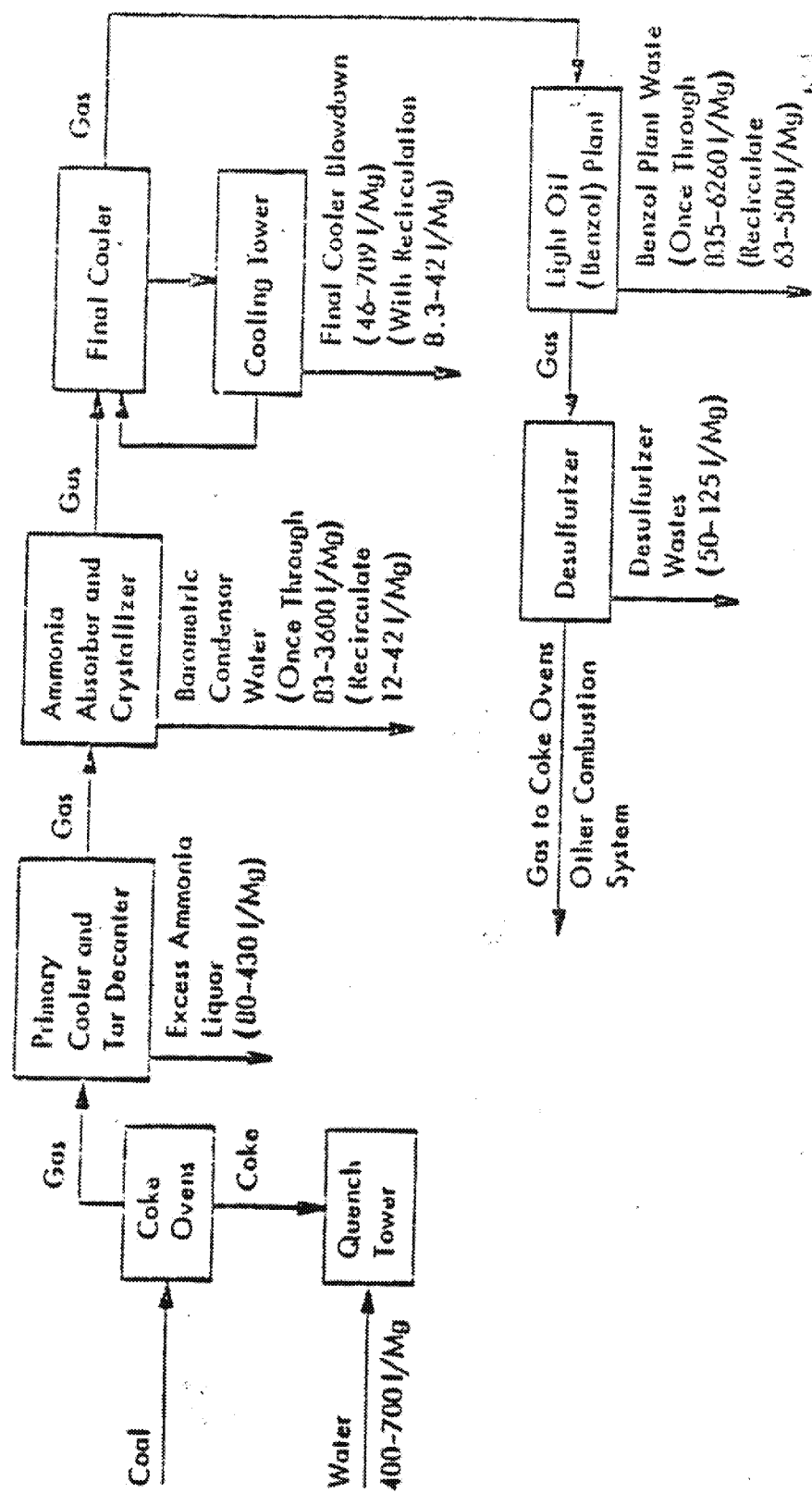


Figure 2. Origin of major coke plant waste streams.

TABLE 2. RAW WASTEWATER ANALYSIS FOR COKE BYPRODUCT RECOVERY PLANTS<sup>a</sup>

Waste stream	Water, b volume L/Hr	Total dissolved solids mg/L	Total suspended solids mg/L	Ammonia mg/L	Phenolic compounds mg/L	Sulfide mg/L	Cyanide mg/L	Benzene mg/L	Naph- thalene mg/L	Toluene mg/L	Phenol mg/L	Ithio- cyanate mg/L	Oil and grease mg/L	pH
Waste ammonia liquor	160 (75-429)	15,875 <sup>c</sup>	59	5,022 (1,500- 9,041) <sup>d</sup>	1,054	1,039	24.6 (10-200) <sup>d</sup>	9.66	25.6	3.09	382 (200-3,000) <sup>d</sup>	661	130	8.6-9.1
Final cooler blowdown (with recircula- tion)	38.3 (8.3-41.6)	262 <sup>e</sup> 840 <sup>d</sup>	40 <sup>d</sup> 10 <sup>d</sup>	39 (104-1,378) <sup>d</sup>	101	22	188 (153-1,400) <sup>d</sup>	27.8	39	17	59.6 (124-1,482) <sup>d</sup>	54	37	7.3
Benzol plant wastes	71.6 (62.5-500)	1,054 <sup>c</sup>	67 (7.5-9) <sup>d</sup>	198 (5-426) <sup>d</sup>	435	102	31 (2.5-84) <sup>d</sup>	82.8	15.1	8.62	61 (2.4-52) <sup>d</sup>	239	100	6-8.4
Desulfurizer (wet methods)	58.3 (50-125)	N/A	N/A	2,480 <sup>c</sup>	N/A	N/A	3,400 <sup>d</sup>	N/A	N/A	N/A	4 <sup>d</sup>	N/A	N/A	8.6-9.1
Miscellaneous wastes	218 (29-350)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

<sup>a</sup> Unless otherwise indicated, data were compiled from Reference 2.

<sup>b</sup> Values are average of the "best" plants with respect to water recirculation as determined in Reference 30. Numbers in parentheses represent ranges.

<sup>c</sup> Reference 3.

<sup>d</sup> Reference 4.

<sup>e</sup> Reference 5.

<sup>f</sup> Reference 6.

The free ammonia is that which is readily dissociated by heat, i.e., ammonium carbonates, sulphide, and cyanide, while the fixed ammonia is that which requires the presence of a strong alkali to effect displacement of the ammonia from the compound in which it is present, such as ammonium chloride, thiocyanate, ferrocyanide, sulphate, etc.

Contaminated barometric condenser water results from the direct contact of cooling water with vapors released in the crystalizing and concentrating of ammonium sulfate by vacuum evaporation. The result is a waste stream containing cyanides, phenols, naphthalene, and free and emulsified oils.

Final cooler blowdown comprises the water condensed from the gas stream and the spray water used in the direct contact cooling of the gas stream. The amount of blowdown is dependent upon the degree of recirculation of the spray water. The final cooler water contains cyanogen compounds, phenolics, and light oils. Data indicate that final cooler effluent has low concentrations of total dissolved solids.

Light oil (Benzol) plant wastewater will vary according to the extent of light oil recovery. Condensed steam from stripping operations and cooling waters constitute the bulk of the waste stream. Light oil wastewaters contain phenol, cyanide, ammonia, and oil.

One additional wastewater source from the byproducts plant is the discharge from the wet method desulfurizers used by some plants to reduce the sulfur content of the coke oven gas. Few data are available on the types of pollutants associated with these streams.

Scrubber effluent from charging and pushing systems may also be used as makeup. Available data suggest that these streams have low levels of dissolved solids, but that they have very high levels of finely divided suspended particles.

Data on flow rates and solids levels for each of the potential makeup streams are presented in Table 3.

### C. REGULATION OF COKE QUENCH TOWER EMISSIONS

Regulation of air emissions has historically been focused on (1) the total outlet emission rate, proper; or (2) the control of the inputs to a

TABLE 3. SOURCES OF QUENCH TOWER MAKEUP WATER

Water source	Quantity of water available for quenching <sup>a</sup> g H <sub>2</sub> O/Mg coke	Total dissolved solids (TDS), mg/l	Total suspended solids (TSS), mg/l
Excess ammonia liquor	79-430 (160)	15,875 <sup>b</sup>	59 <sup>c</sup>
Final cooler blowdown			
Once through	46-625 (378) <sup>d</sup>	262 <sup>e</sup>	40 <sup>c</sup>
Recirculated	8.3-42 (38)	840 <sup>e</sup>	40 <sup>c</sup>
Benzol plant			
Once through	625	1,054 <sup>b</sup>	67 <sup>c</sup>
Recirculated	63-500 (72)	1,054 <sup>b</sup>	67 <sup>c</sup>
Barometric condenser			
Once through	83-625 (625) <sup>d</sup>	NA <sup>f</sup>	NA
Recirculated	12-42 (46)	NA	NA
Scrubber blowdown			
Charging	21-104 <sup>g</sup>	NA	9,200 <sup>g</sup>
Pushing	625 <sup>h</sup> 420 <sup>g</sup>	450 <sup>i</sup>	3,202 <sup>i</sup> 2,260 <sup>g</sup>
Other noncontact cooling			
Water blowdown	625	510 <sup>i</sup>	32 <sup>i</sup>
Natural water sources			
Lake Erie	625	170 <sup>j</sup>	NA
Lake Michigan	625	160 <sup>j</sup>	NA
Ohio/Mahoning River, avg.	625	180 <sup>j</sup>	NA
Allegheny/Monongahela River, avg.	625	373 <sup>j</sup>	NA
Typical industrial, avg.	625	42-435 (171) <sup>k</sup>	NA

<sup>a</sup> Unless otherwise stated, ranges were obtained from Reference 2, pp. 37-41. Averages shown in parentheses are based on the data from responses to Section 114 information requests. Maximum water use is assumed to be 625 g/Mg of coke.

<sup>b</sup> Reference 3.

<sup>c</sup> Reference 2, pp. 42-45.

<sup>d</sup> Average of high and low values from Reference 2, pp. 37-41.

<sup>e</sup> Reference 5.

<sup>f</sup> NA - data not available.

<sup>g</sup> Reference 9.

<sup>h</sup> Reference 10.

<sup>i</sup> Based on average of all plants, Reference 2, p. 46.

<sup>j</sup> Reference 11.

<sup>k</sup> Based on average TDS level in public water supply for 20 cities in which coke plants are located.

quench tower system (i.e., water quality); or (3) the type of system used (i.e., baffle design). To enforce the emission rate regulation, a method for compliance testing is required. Testing of quench tower air emissions is expensive.\* A method for testing quench towers is not specified in the current Ohio SIP, leaving the Agency to use "the appropriate procedures and methods of PART 60," as the testing guide. (This language is derived from 40 CFR Part 50.12(c); and refers to 40 CFR Part 60, Appendix A, the EPA's New Source Performance Standards testing section.) Therein is found a technique, "Method 5," which is not directly applicable to quench towers (all recent tests have used a modified version of Method 5). More importantly, Method 5 is not directly useable at some Ohio towers because the baffles are so high in these towers that testing cannot physically be performed. J&L's Campbell Works is one such plant.

Nevertheless, a modified test method can be specified, as the experiences from the work conducted at DOFASCO, Gary and Lorain show. This is exactly what EPA stated in its rulemaking on the Michigan iron and steel SIP (46FR27923-5/22/81).

Regulations of the first two types, (2) and (3) above, which focus upon the variables which affect quenching emissions, bypassing the highly technical, costly, and sometimes impractical direct testing approach, have been undertaken to limit quench tower emissions. Examples of these are:

- Illinois in 1972 required that all coke quenching operations be "enclosed."
- In 1979, Indiana limited total dissolved solids (TDS) to a specific value, 1,500 mg/l, for tower make-up water.
- Allegheny County, PA eliminated the use of contaminated wastewater from quenching operations, requiring the use of water of the same quality as is dischargable to the nearest river (on the order of 750 mg/l).
- Ohio (removing the process weight rule from its own code), requires the use of baffles.

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\*Of the projects discussed in this paper, none have been tested for less than \$100,000.

Associating a specific air emission rate with this form of coke quench tower emissions regulation is difficult because variables other than those specified in the regulation may also influence emissions. For instance, two towers may both use multidirectional baffles per some legal requirement, but may not have the same emission rate because the two towers use different methods of quenching or because the two towers have different exit velocities.

#### D. COMPLIANCE ALTERNATIVES

##### 1. Baffles

A baffle is a set of wooden, plastic, stainless steel, or other corrosion resistant surfaces placed in a tower to impede the emission of particulates and droplets. Figure 3 shows typical baffle arrangements. They may take a variety of forms but generally are of two types--either as a single horizontal row or a multiple row of baffles. The single row can be placed in a number of angles settings and the spacing between rows also varies widely. The multiple row baffles can either be one where two or more single rows are placed above one another in opposing directions, or, as in the case of DOFASCO '81, a baffle specifically manufactured to control water droplets was installed. This manufactured removal device is not the typical 2 x 10 inch wooden plank placed 6 to 10 inches apart at angles of 45° but a mist eliminator wherein water droplets and particles must enter through 1/2 inch openings and change directions more than four times within 12 inches before exiting.

Other than the manufactured baffles by the Munters Company and the "A"-frame design by Carl Still, most baffles are presently constructed of wood. The design of a noncommercial baffle system must be such that several rows, are placed approximately 45° in opposing directions and are positioned such that each plank is less than 6 inches (end to end) apart allowing an overlap for each plank (assuming use of 10 x 12 inch planks). Ninety five (95) percent of the tower's cross-sectional area should be covered. The baffles should be placed in the upper two-thirds of the tower and a spray system should be used to clean the baffles. The entire system should also be

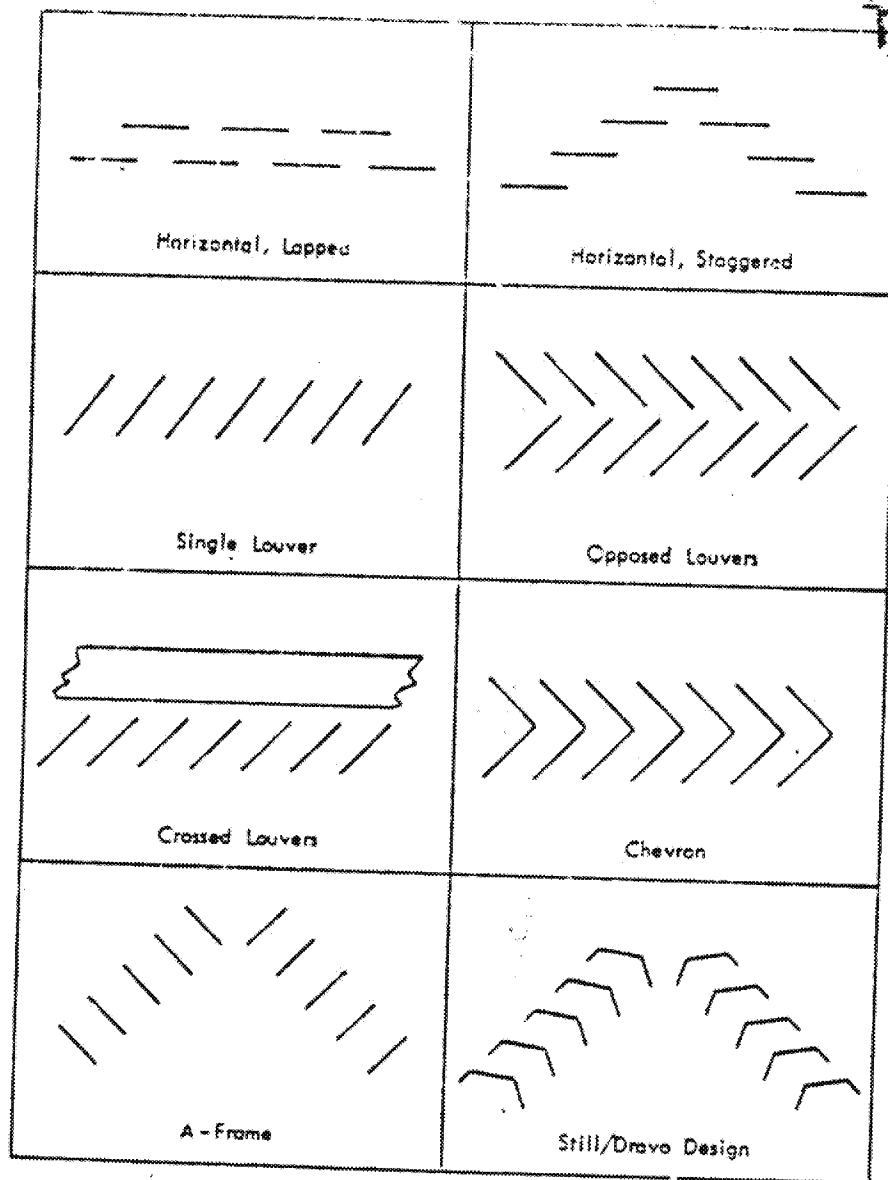


Figure 3. Typical baffle configurations.

inspected monthly to check on baffle condition, particle buildup, and spray cleaning equipment operation.

A possible definition of a high efficiency baffle system, based on the results from the DOFASCO '81 tests, would be one that meets or exceeds the 70 percent removal efficiency. Present information shows that several designs are capable of this efficiency or have outlet emission rates consistent with the DOFASCO '81 results.

## 2. Water Quality and Treatment Controls

The quality of water used for quenching is one of the specific factors which affects emission rates. The phrase "clean water quenching" refers to the spraying of coke with water containing low TDS ( $\leq 1,500$  mg/l) concentrations. The main source of high TDS water ( $> 1,500$  mg/l) is a waste stream known as the "flushing liquor," which is generated in the coking process. This wastewater is derived from the coal <sup>which</sup> ~~and~~ contains 5 to 10 percent water by weight. When heated in a coke oven, this water is driven off and collected in the byproduct collection main. This wastewater contains chlorides, sulfates, ammonia, cyanides, and many other organic species. Coke plants traditionally had disposed of this liquor as part of the make-up water to a quench tower. Since make-up water needs (approximately 100 gallons/ton coal) exceed flushing liquor generation by a factor of three, plants using flushing liquor as a quenchant will usually use all of it for that purpose. If this waste liquid is barred from quenching use, it still needs disposition some place. The other available methods are: (1) direct disposal to a receiving body; (2) treatment of  $\text{NH}_3$ , CN, and phenol, and then disposal to a receiving body); (3) dispose of contaminated process water to a municipal wastewater plant.

Treatment of these chemical species usually requires installation of equipment (ammonia stills and biological oxidation plants), which also oxidizes other organic components, as well. Pretreatment requirements at the coke plant still may impose disposal costs, however, it is probable that municipal plants will not accept these wastes.

If wastewater is used for quenching, its use may produce severe corrosion of a plants steelworks. Although it is difficult to show that avoiding this problem itself justifies the cost of water treatment, many plants have abandoned the practice of "dirty water" quenching. A little over 50 percent of the coke produced in the United States is quenched with "dirty water" based on available DSSE data.

### III. RELEVANT PARTICULATE MASS EMISSIONS TEST DATA

Quench towers present difficult sampling problems due to their high moisture contents, short quenching durations, nonlinear flows, and difficult physical access. Quench tower emissions have been measured by methods which reduce the effects of these problems only since 1976. The tests listed on and summarized in the appendix are ones which the Agency believes satisfy the measurement problems stated above. These tests were performed on the outlet (atmospheric) side of the baffled towers by methods developed specifically for these quench towers. They are:

<u>Source</u>	<u>Date of test</u>	<u>Tester</u>
U.S. Steel, Lorain	9-10/76	Contractor for EPA (York Research)
U.S. Steel, Gary No. 3	12/79	Contractor for U.S. Steel (TRC)
U.S. Steel, Gary No. 5	12/79	Contractor U.S. Steel (TRC)
DOFASCO*	9/79	Contractor for DOFASCO
DOFASCO	10/81	Contractor for EPA (GCA/Technology)

The results of these tests indicated to the Agency the magnitude of quench tower emissions and the process variables that affect these rates. These are some of the more important factors which are known or believed to affect quench tower emission rates:

<u>Variable</u>	<u>Probable effect</u>
Greenness of coke	Greener coke means more emissions.
TDS level	Emissions increase linearly with TDS concentration.

\*Dominion Foundry and Steel Co., Ltd., Hamilton, Ontario.

Variable	Probable effect
Tower design	Emissions increase as velocity of exhaust increases because of a "carryover" effect.
Spray method	"LoMo" quenching (i.e., streaming water deep into the coke bed produces more emissions than top spraying).
Baffles	Lower emissions if a multidirectional baffle is used rather than a single row however a single row baffle produces less emissions than no baffles at all.

These tests were conducted over a variety of conditions at each plant but not over the entire domain of each variable. For instance, the Gary tests were conducted in the 500 to 2,100 mg/l TDS range while the DOFASCO '77 tests were conducted at the lower end of this range. The Lorain tests spanned 500 to 13,000 mg/l. These data were used to develop for each practical Ohio condition (i.e., tower type, baffle type, quench water quality) a predictive formula relating emissions, Q (lb/ton coal) to water quality (TDS-mg/l) of the form:

$$Q \text{ (lb/ton coal)} = A + B \text{ (TDS-mg/l)}$$

The constants A + B, respectively, contain the technical influences of the nonwater related factors and the water and tower related factors based on linear regression analysis.

Table 4 shows the three cases that have been developed from the existing data base. Table 5 shows the towers that are affected versus which towers these conclusions are based upon.

The Lorain tower, which the steel industry has asserted produces unrepresentative "high" emission rates as a result of an alleged "carryover" effect due to velocities in excess of those found in the other towers tested, may produce higher emissions than from larger similarly baffled towers. Thus, the constant, A, would be expected to be larger for Lorain. Lorain is an example of a fast/single row baffle tower.

TABLE 4. QUENCH TOWER EMISSION RATES AS A FUNCTION OF TOTAL DISSOLVED SOLIDS CONCENTRATIONS

Case A--Uncontrolled

$$Q = (\text{lb/ton coal}) = 1.22 + 0.000411 (\text{TDS}) \text{ Inlet to Baffles}$$

$$r = 0.860$$

DOFASCO '81

Ranges--Emissions 0.42 - 6.69  
TDS 490 - 11,900

Case B--Controlled/Multidirectional Baffles

$$Q = (\text{lb/ton coal}) = 0.296 + 0.000107 (\text{TDS}) \text{ DOFASCO '77 and '81}$$

$$r = 0.724$$

Gary #3

Ranges--Emissions 0.20 - 2.01  
TDS 400 - 11,900

Case C--Controlled/Single Row Baffles--Slow Tower

$$Q = (\text{lb/ton coal}) = 0.249 + 0.000245 (\text{TDS}) \text{ Gary #5}$$

$$r = 0.724$$

Ranges--Emissions 0.29 - 0.75  
TDS 452 - 1,800

Case D--Controlled/Single Baffles--Fast Tower

$$Q = (\text{lb/ton coal}) = 1.31 + 0.000144 (\text{TDS}) \text{ Lorain}$$

$$r = 1$$

Ranges: Emissions 0.75 - 5.97  
TDS 500 - 13,000

$Q$  = Emissions; front half EPA Method 5 particulates, lb/ton coal changed (wet).

TDS = Total dissolved solids (mg/l).

Note: It should be noted that TDS was determined in all of these studies using an evaporation temperature of 103 to 105°C and not 180°C.

TABLE 5. QUENCH TOWER TYPES

Type	Affected other facilities	Similar towers studied
<u>Rectangular</u>		
Approximately 50 to 80 ft high	RSC/Youngstown	Gary No. 5
Outlet--40 x 20 ft	Warren	Gary No. 5
Single row wooden	USSC/Lorain	Gary No. 5
Baffles @ 45°		DOFASCO '77--multi-directional baffles
Slow velocity		DOFASCO '81--multi-directional baffles
<u>Circular</u>		
Approximately 100 to 130 ft high	Jones & Laughlin	Lorain
12 to 20 ft dia		
Single/multidirectional	USSC/Lorain	
Wooden baffles		
High velocity		
<u>Offset</u>		
Approximately 110 ft high		Gary No. 3
Outlet 25 x 25 ft		
Brick base-flow		
Diverted into wooden tower		
"A" frame plastic baffles		
Slow-medium velocity		
Velocity ranges--		
Slow 0 to 12 fps		
Medium 12 to 20 fps		
High 20 fps and up		

The multidirectional baffled, fast towers at J&L's plant require the use of other elements of the data base. Particularly relevant are the multidirectional baffle data of Gary No. 3 (but on a slow tower), DOFASCO '81 (see next subsection), and Lorain. The Gary No. 3 tower is of an "offset" tower design so that its outlet emission rate reflects its baffles and tower design.

The simpler single row, slow towers of RSC required particular attention to the Gary No. 5 slow tower data. However, as consideration was given to its possible emission rates with multidirectional baffles, the DOFASCO '81 data were also used.

The relevant data collected by EPA through the end of the summer of 1981 is as shown in Table 6.

TABLE 6. DATA COLLECTED PRIOR TO FALL 1981

Test	TDS level of quench water	Modified Method 5 front half emission rate
DOFASCO-'77	400 mg/l	0.27 lb/ton coal
Gary No. 3 '79	446 mg/l	0.33 lb/ton coal
	1,588 mg/l	0.43 lb/ton coal
Gary No. 5 '79	466 mg/l	0.32 lb/ton coal
	1,404 mg/l	0.64 lb/ton coal
Lorain '76	1,050 mg/l	1.46 lb/ton coal
	9,850 mg/l	2.73 lb/ton coal

#### A. DOFASCO TESTS, 1981

In the fall of 1981, tests were conducted at another DOFASCO quench tower by an EPA contractor. The purpose of this program was to test baffle efficiency, to acquire particulate emission rates, and to study these over a range of TDS concentrations. The test included:

- (1) Simultaneous modified Method 5 sampling performed above and below a set of multidirectional baffles. Inlet and outlet emission rates were therefore measured.
- (2) Size distribution tests of the emissions on both sides of the baffles.

#### 1. Results

For each part of the TDS spectrum, both above and below the baffles, both front half and full train results are reported for the DOFASCO '81 tests. The results are divided into two groups. The "inlet" results represent the uncontrolled, raw emission rate (if the baffles were not present). The outlet results represent controlled emissions (after the baffles). The summary of these results follows:

- (1) At TDS levels of about 8,850 mg/l:

<u>Uncontrolled</u>	<u>Controlled</u>
5.32 lb/ton	1.39 lb/ton

- (2) At TDS levels of about 510 mg/l:

<u>Uncontrolled</u>	<u>Controlled</u>
1.19 lb/ton	0.34 lb/ton

Results from the DOFASCO '81 tests are shown in Table 7.

#### B. ANALYSIS OF QUENCH TOWER TEST DATA

These data are presented below in the form of a graph (Figure 4) which display these data in the form of plots of air emission rate against TDS concentration. This graph shows these major points:

- (1) Water quality (TDS quench water) is an independent variable affecting air emission rates.

TABLE 7. QUENCH TOWER EMISSION RATE SUMMARY: DOFASCO--1981 TOWER NO. 1  
[POUNDS PER TON OF COAL CHARGED (lb/t coal)]

Test series	Quench water TDS (mg/l)	Cyclone with nozzle	Front half without cyclone	Front half total	Back half	Full train
I. Inlet uncontrolled		0.93	0.26	1.19	0.12	1.25
Outlet controlled	510	0.26	0.08	0.34	0.17	1.47
II. Outlet <sup>a</sup> controlled	2270	0.42	0.06	0.48	0.40	0.88
III. Inlet uncontrolled		3.96	1.36	5.32	0.55	5.87
Outlet controlled	8850	0.66	0.73	1.39	0.77	2.16

<sup>a</sup>Outlet testing only.

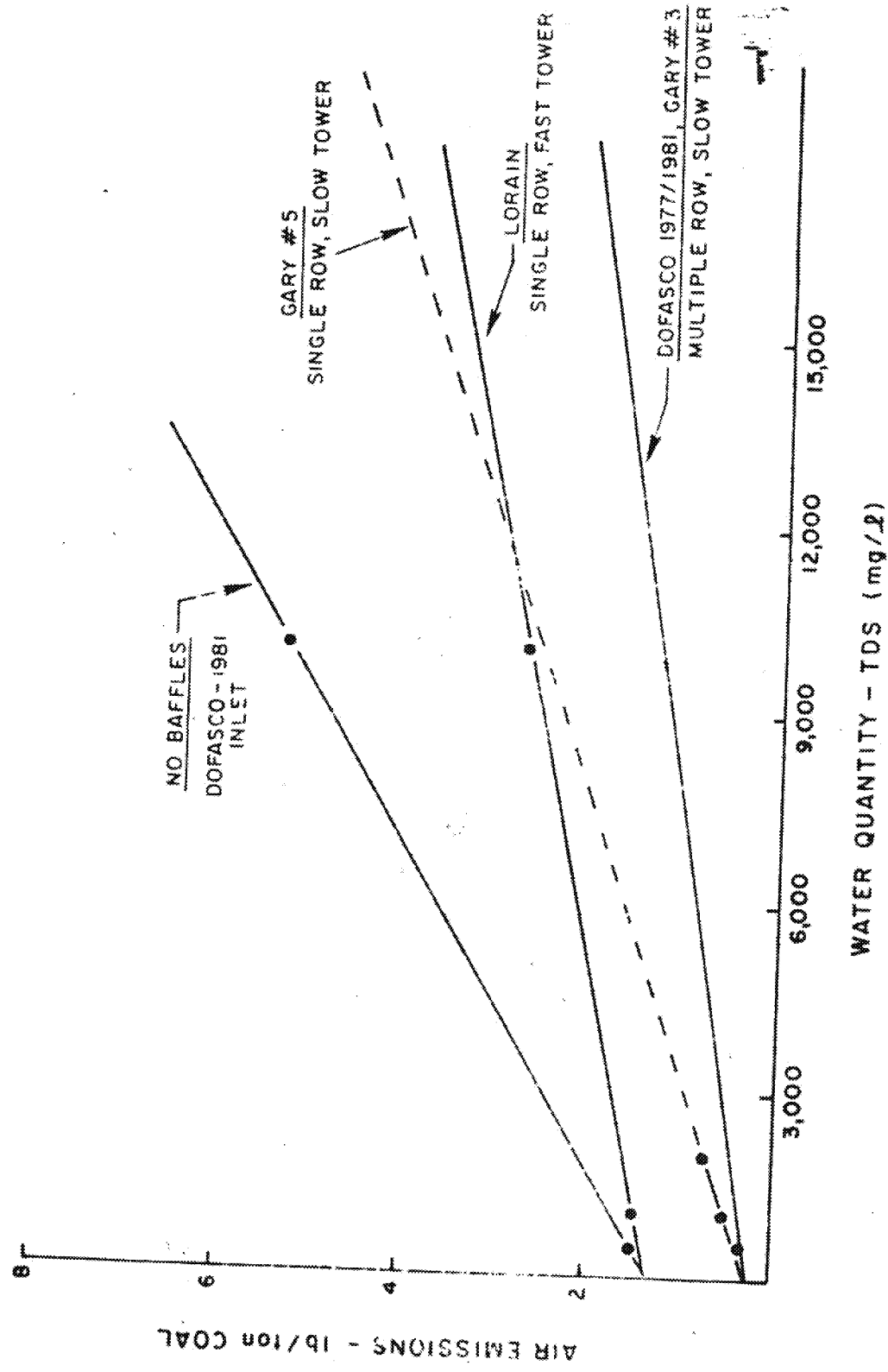


Figure 4. Air emission vs. water quality.

- (2) A linear relationship exists between air emissions and TDS in the Lorain data set over the range 500 to 13,000 mg/l TDS. The slope of the Lorain curve is consistent with the Gary-DOFASCO '77 data set in the 400 to 2,000 mg/l range.
- (3) The Lorain curve is offset upwards from the Gary curve, as a result of the combination of factors listed at the outset of Section II.
- (4) At low TDS concentrations, the variability of specific data points around the best fit regression line is considerable. This suggests that such variables as spray method tower design, etc., influence air emissions, each a relatively small amount. (The value of which is not known due to the small data base and the expenses needed to determine them.) This conclusion is reflected in different values for the A constant, discussed previously.

Collectively, these points suggest a basis for regulating air emissions via specifications of quench water quality, and in the type of tower and quenching used.

### Conclusions

### Technical Implications of these Data

- (1) Inlet test results (underneath the baffles) shown in Figure 4 vary from 1.19 lb/ton to 5.32 lb/ton, depending on quench water TDS concentration. Since the inlet results are virtually the same as those that would occur in an unbaffled tower, the inlet measurement is a measure of emissions from an uncontrolled tower.
- (2) Uncontrolled rates plainly increase as the dissolved solids in the water increase. The "outlet" curve of Figure 4 shows three points connected by a straight line indicating that even with these baffles, emissions are still linearly dependent on quench water TDS. This is the same conclusion as was reached from a study of the pre-DOFASCO '81 tests.
- (3) Baffle efficiency ranged from 71 percent to 74 percent.\* The implication of this result is that baffle

---

\*Lower TDS series (510 mg/l TDS)

$$\frac{\text{Inlet} - \text{Outlet}}{\text{Inlet}} \times 100 = \%$$

$$\frac{1.19 - 0.34}{1.19} \times 100 = 71\%$$

Higher TDS series (9,850 mg/l TDS)

$$\frac{5.32 - 1.39}{5.32} \times 100 = 74\%$$

efficiency is independent of the salt concentration of the droplets formed during quenching.

- (4) These results indicate that it seems reasonable to conclude for Ohio towers that the compliance air emission rate (based on a "modified method 5" front half test method) of 0.75 to 0.90 lb/ton of coal was achievable if TDS levels were reduced to the vicinity of 1,500 mg/l of quench water. The essential specific facts giving rise to this conclusion are that the Gary No. 3 and No. 5 baffled towers were tested at make-up quench water TDS concentration of approximately 1,500 mg/l and produced an air emission rate of less than 0.45 and 0.65 lb/ton of coal, respectively.
- (5) All baffles do not behave identically. The Gary No. 5 tests indicate an emission of 0.64 lb/ton at 1404 mg/l; while DOFASCO '81 data indicate 0.48 lb/ton at 2270 mg/l. The same measurement techniques were used and the towers are similar.

Differences in baffle design exist and these may lead to an air emission rate of 3.2 lb/ton at 8850 mg/l using the single row calculation from Table 4 whereas the multidirectional baffle system at DOFASCO produced actual emissions of 1.19 lb/ton. At even higher levels, e.g., 12,000 mg/l TDS, the baffles differences could be accentuated.

All baffles therefore are not of the same effectiveness and care is needed in specifying the type which would be needed in decisions based on baffle solutions.

#### IV. APPLICATION OF EMISSIONS DATA TO OHIO COKE PLANTS

There are nine coke plants in Ohio affected by the SIP rulemaking. These are listed in Table 8. Estimating their emission rate requires knowledge of the type of tower, baffle, method of spraying, and water quality. These, and other basic description facts are shown in this table and in Table 5. Note that in the Ohio area, there are a variety of quench tower configurations.

The results of all the emission tests reported in Section II are summarized in the emissions formulae of Table 4, along with the basis for each formula. These formulae are then used to develop the emissions for each of the principal plants affected by this rulemaking decision, shown in Table 9.

Several control strategies are illustrated in these tables.

- o Improve baffles without modifying water quality. Usually this means installing well-designed, multidirectional baffles.
- o Quench with clean water without replacing the baffles or changing the tower design. TDS of 1500 mg/l is assumed for quench water quality. This strategy means contaminated water must otherwise be disposed of elsewhere.
- o Improve both baffles and quench water (multidirectional baffles and 1500 mg/l TDS quench water).

Table 10 show the effective emission rates associated with the four affected Ohio plants, as a result of these strategies. Note that in the aggregate emission rates are on the order of ten thousand tons per year (10,000 tpy) now (at capacity). The table also indicates the aggregated reductions which would occur under the above three scenarios for the plants shown in Table 8.

TABLE 8. OHIO COKE OVEN FACILITIES--AFFECTED BY THE OHIO TSP DECISION

Plant/location blast furnace coke	Battery designation	Startup	No. of ovens per battery	No. of towers	Quench circumstances
AKNO Steel, Hamilton Plant, Hamilton, Ohio... announced for closure	No. 1	Rebuild 1961	45	1	Tower type unknown. Baffles stainless steel--two rows--10" high. Clean Water Quenching (i.e., full treatment of NH <sub>3</sub> liquor). TDS-N.A. Assumed to be less than 1,500 mg/l.
	No. 2	1938 rehab 1976	15		
	No. 3	1941 rehab 1977	25		
	No. 4	1947 rehab 1978	26		
J&L Steel, Campbell Works, Campbell, Ohio	No. 7	1954	76	2	Round Brick Tower(s) 31 m high--4.3 m diameter four rows of wooden baffles at opposing 45°--extension to brick stack TDS approximately 14,000 mg/l.
	No. 9	1958	76		
Republic Steel, Mahoning Valley District, Warren, Ohio	No. 4	1979	79	1	Rectangular Tower 15.5 m x 18.5 m x 6 m. Single row wooden baffles at 45° approximately 16.3% of total quench water volume is process wastewater. TDS-N.A.
Republic Steel, Cleveland District, Cleveland, Ohio	Plant No. 1			2	Rectangular tower(s) 15.5 m x 18.5 m x 6 m. Single row wooden baffles approximately 62.1% of total quench water volume is process wastewater. TDS-833 mg/l.
	No. 1	11/76	51		
	No. 2	1958 (rehab 1972)	51		
	No. 3	1958 (rehab 1972)	51		
	No. 4	1952 (rehab 1972)	51	1	Round brick tower. No data on baffle type 28.3% of total quench water volume is process wastewater--recirculated dirty quench water TDS-N.A.
	Plant No. 2				
	No. 6	1952 (rehab 1979)	63		
Republic Works, Youngstown Works, Youngstown, Ohio	No. 7	1952 (rehab 1979)	63	2	No data on tower types--Single row wooden baffles at 45° 11.1% of total quench water volume is process waste water--recirculated dirty quench water TDS-N.A. Assumed to be 1500 mg/l.
	A	1950 (1949)	38		
	B	1950	65		
	C	1950 (rebuild 1962)	59		
U.S. Steel, Lorain Plant, Lorain, Ohio	G	1956 (rehab 1977)	59	5	3-round brick towers 37 m high, 4.7 m diameter. Single row wooden baffles at 45°--located at base of tower. 2-rectangular brick towers 15.5 m x 18.5 x 6 m. Single row wooden baffles at 45° 72.8% of total quench volume from process wastewater--recirculated dirty quench water. TDS - 9000 mg/l.
	H	1955 (rehab 1978)	59		
	I	1955 (rehab 1978)	59		
	J	1947 (rehab 1970)	59		
	K,L,D	(scheduled for shutdown)	59		

Table 9  
Emission Rate Scenarios  
for the Affected Ohio Facilities<sup>1</sup>

	Jones & Laughlin	RSC Youngstown	RSC Warren	U.S. Steel Lorain
Production Rate tpd	2400 tpd	2000 tpd	1650 tpd	3200 tpd
mtpy	0.88 mm	0.73 mm	0.60 mm	1.17 mm
Current TDS mg/l	14,000	12,000	12,000	10,000
Current Emissions lb/t. coal	1.79 - 3.33 <sup>2</sup>	3.19 <sup>4</sup>	3.19 <sup>4</sup>	2.73 <sup>6</sup>
tpy	1170 - 2180	1740	1440	2385
Install Multi-Directional Baffles				
lb/t. coal	1.79 - 3.33 <sup>2,3</sup>	1.58 <sup>5</sup>	1.58 <sup>5</sup>	1.37 - 2.75 <sup>2</sup>
tpy	1170 - 2180	860	710	1200-2400
Leave Existing Baffles in place -				
Quench Water to 1500 mg/l				
lb/t. coal	0.46 - 1.53 <sup>2</sup>	0.62 <sup>4</sup>	0.62 <sup>4</sup>	1.60 <sup>7</sup>
tpy	300 - 1000	340	280	1400
Install Multi-Directional Baffles				
Quench Water to 1500 mg/l				
lb/t. coal	0.46 - 1.53 <sup>2</sup>	0.46 <sup>5</sup>	0.46 <sup>5</sup>	0.46 - 1.53 <sup>2</sup>
tpy	300 - 1000	250	210	400-1330

<sup>1</sup>Available data shows RSC-Cleveland using 1500 mg/l TDS or less quench water

<sup>2</sup>Using Case B and Case D (for high velocity rates) Table 4

<sup>3</sup>Already has multi-directional baffles

<sup>4</sup>Using Case C, Table 4

<sup>5</sup>Using Case B, Table 4

<sup>6</sup>Actual Test Data

<sup>7</sup>...

Table 10  
Emission Rate Changes

Plant	Current Emissions	Replace with Multi-Directional Baffles	Improve Water Quality to 1500 mg/l TDS	Replace with Multi-Directional Baffles Water @ 1500 mg/l TDS
Jones & Laughlin TPY % Change <sup>1</sup> (mean value)	1170-2180 <sup>3</sup> ---	1170-2180 <sup>3</sup> 0%	300-1000 <sup>3</sup> 74%-54%	300-1000 <sup>3</sup> 74%-54%
RSC/Youngstown TPY % Change	1740 ---	860 51%	340 80%	250 86%
RSC/Warren TPY % Change	1440 ---	710 51%	280 81%	210 85%
USS Lorain TPY % Change (mean value)	2385 ---	1200-2400 <sup>3</sup> 25%	1400 41%	400-1330 <sup>3</sup> 41%
Totals <sup>2</sup>				
TPY	7240	5045	2670	1975
Avg % Reduction <sup>2</sup>	---	32%	67%	69%

<sup>1</sup> % change from Status Quo

<sup>2</sup> Using the means of the J&L/Lorain Ranges

<sup>3</sup> Case D, Table 4, for the upper value

Table 9  
Emission Rate Scenarios  
for the Affected Ohio Facilities<sup>1</sup>

	Jones & Laughlin	RSC Youngstown	RSC Warren	U.S. Steel Lorain
Production Rate tpd	2400 tpd	2000 tpd	1650 tpd	3200 tpd
mtpy	0.88 mm	0.73 mm	0.60 mm	1.17 mm
Current TDS mg/l	14,000	12,000	12,000	10,000
Current Emissions lb/t. coal	1.79 - 3.33 <sup>2</sup>	3.19 <sup>4</sup>	3.19 <sup>4</sup>	2.73 <sup>6</sup>
tpy	1170 - 2180	1740	1440	2385
Install Multi-Directional Baffles				
lb/t. coal	1.79 - 3.33 <sup>2,3</sup>	1.58 <sup>5</sup>	1.58 <sup>5</sup>	1.37 - 2.75 <sup>2</sup>
tpy	1170 - 2180	860	710	1200-2400
Leave Existing Baffles in place -				
Quench Water to 1500 mg/l				
lb/t. coal	0.46 - 1.53 <sup>2</sup>	0.62 <sup>4</sup>	0.62 <sup>4</sup>	1.60 <sup>7</sup>
tpy	300 - 1000	340	280	1400
Install Multi-Directional Baffles				
Quench Water to 1500 mg/l				
lb/t. coal	0.46 - 1.53 <sup>2</sup>	0.46 <sup>5</sup>	0.46 <sup>5</sup>	0.46 - 1.53 <sup>2</sup>
tpy	300 - 1000	250	210	400-1330

<sup>1</sup> Available data shows RSC-Cleveland using 1500 mg/l TDS or less quench water

<sup>2</sup> Using Case B and Case D (for high velocity rates) Table 4

<sup>3</sup> Already has multi-directional baffles

<sup>4</sup> Using Case C, Table 4

<sup>5</sup> Using Case B, Table 4

<sup>6</sup> Actual Test Data

<sup>7</sup> From Figure 4, Table 4, 1500 mg/l TDS

TABLE III-4

## GENERAL SUMMARY TABLE - BY-PRODUCT COKEMAKING

Plant Code No.	First Year Prod.	Rebuild Active Batteries Oldest Newest	Production, TPD		Typical GPD	Typical White Flow	Operations DS.		By-Products		Control & Treatment Tech.				In vs. Ret.	Discharge Mode With Typical CPT for each Ret. Direct POTW Quench Other	
			Rated Capa- city	City			Nil GPT	APT	SOH	RTX	OTH	ASF	ASC	DP			CH
TARRANT COKE																	
0012A	1920	1951	1979	(2400)	(1750)	324,000	(181)	1	N	APS	N	C	Y	ASC	N	BOA2	Ret (148) 0 (117)
0012B	1919	1966	1967	(1300)	(990)	91,000	(92)	1	N	APS	N	C	Y	ASC	N	BOA1	Ret (152) 0 0
0024A	1916	1967	1979	3480	2578	446,400	173	2	D	APH	Y	C	Y	ASC	N		Ret 0 173 0
0024B	1901	1968	1968	2150	2000	86,000	43	N	N	N	N	N	N	N	N		Ret 0 0 0
ARMCO-Middleton																	
0060A	1928	1953	1977	5150	4890	780,600	160	1	88	APS	Y	R	(2)	Y	ASL	Y	Ret 0 160 0
0060B	1928	1959	1969	1910	1811	231,800	128	1	25	APS	Y	R	(2)(3)	Y	ASL	Y	Ret 131 0 0
0060F	1943	1950	1953	1045	840	37,000	44	N	N	N	N	N	(2)(3)	Y	ASL	Y	Ret 131 0 0
0112	1914	1951	1976	(5840)	(5058)	840,000	(166)	1	D	APS	N	C	(2)(3)	N(7)	ASL	N	In 0 0 0
0112A	1920	1951	1980	9800	9163	834,000	91	1	20	APS	N	R	(2)(3)	N(7)	ASL	N	Ret (104) (<1) (122)
0112B	1924	1948	1970	8140	6908	760,000	110	1	8	APS	Y	R	(2)(3)	N(7)	ASL	N	Ret 158 0 0
0112C	1921	1965	1965	1100	998	61,000	61	1	N	APS	Y	C	(2)	N(7)	ASL	Y	In 0 0 47
(R)																	Ret 0 0 68
0112C	1926	1948	1952	3500	3028	530,700	175	1	N	APS	Y	C	(2)	Y	ASL	N	Ret 0 0 180
(F)																	
0112D	1969	1969	1979	6670	5179	488,000	94	1	22	APS	N	N	(2)(3)	N	N	N	In 0 0 51
0174	1914	1952	1976	1000	800	28,800	36	1	N	N	N	N	(2)	Y	N	N	In 0 0 0
0196A	1918	1960	1974	*	*	*	*	1	N	APS	N	R	(2)	Y	N	N	In 0 0 0
0212	1909	1946	1946	1086	1002	256,500	256	N	D	N	N	N	(2)	Y	N	N	In 0 0 0
0248A	1912	1948	1951	1200	1050	124,500	128	1	N	APS	Y	R	(2)	Y	N	N	In 0 0 0
(G)																	
0256E	1964	1964	1964	1145	1145	262,000	229	N	N	N	Y	C	(2)	Y	ASC	Y	Ret 0 136 0
0272	1919	1948	1968	3004	3004	312,500	104	1	13	APS	Y	C	(2)	Y	N	N	No Trt 94 0 139
0280B	1929	1963	1963	940	880	173,500	197	1	21	N	N	N	(2)	Y	ASL	Y	Ret 43 0 89
0304	1926	1950	1958	360	Unk	Unk	Unk	1	N	APS	N	N	(2)	Y	ASL	N	Ret 0 82 115
0320	1962	1962	1972	4340	3945	(1,227,600)	(311)	1	N	APP	N	C	(2)	Y	ASL	N	In Unk 0 0
0380	1919	1973	1973	400	340	Unk	Unk	1	D	APS	Y	N	(2)	Y	ASL	Y	In 0 305 0
0384	1913	1959	1980	6170	5640	908,000	161	1	N	APS	Y	C	(2)	Y	ASL	Y	In Unk 0 0
-2-																	
0384A	1943	1974	1974	2500	1562	354,600	227	1	D	APS	Y	C	(2)(3)	Y	ASL	Y	In 0 51 110
-3-																	
0384A	1978	1978	1978	3014	2740	Unk	Unk	1	D	APS	Y	C	(2)(3)	Y	ASL	Y	In 0 147 92
-4-																	
0386A	1906	1955	1955	1740	1660	1,584,000	1085	1	N	APS	N	C	(2)	Y	ASL	Y	In 0 Unk Unk
0396C	1906	1953	1953	814	702	979,300	1395	1	N	APS	N	R	(2)	Y	ASL	Y	Ret 0 1085 0
0402	1917	1953	1977	*	*	*	*	2	D	APH	Y	R	(2)	Y	ASL	Y	No Trt 0 1395 0
0426	1920	1958	1979	2760	2400	316,800	132	1	N	APS	N	C	(2)	Y	ASL	Y	Ret 0 1085 0
0432A	1926	1945	1976	6946	4504	662,000	147	1	N	APS	N	C	(2)	Y	ASL	N	Ret 196 0 0
0437B	1919	1953	1961	5300	5230	243,000	142	1	N	APS	N	R	(2)	Y	ASL	N	In 0 0 0
0448A	1942	1951	1959	4100	3800	201,400	53	1	N	APP	N	C	(2)	Y	ASL	Y	Ret 148 0 0
0464B	1918	1978	1978	530	500	45,000	90	2	N	APP	N	C	(2)	Y	ASL	Y	Ret 0 0 60
0464C	1925	1952	1978	615	600	20,000	33	2	N	APP	N	C	(2)	Y	ASL	Y	In 0 96 0
0464E	1914	1970	1979	2100	1272	234,050	184	2	N	APP	N	C	(2)	Y	ASL	N	Ret 0 11 0
0464F	1914	1970	1979	2100	1272	234,050	184	2	N	APP	N	C	(2)	Y	ASL	N	Ret 236 0 0

TABLE III-4  
GENERAL SUMMARY  
BY-PRODUCT COKE MAKING  
PAGE 2

Plant Code No.	First Year Prod.	Rebuild Active Batteries Oldest Newest	City	Production, TPD		Typical GPD	Typical Raw (t)		Operations			By-Products			Control & Treatment Tech.			In vs. Ret	Discharge Mode With Typical CPT for each Direct POTV Quench Other		
				Rated Capa- city	City		Basic Flow	CPT	NH3 GPT	DS. CPT	APT	GOL	BTX	OTH	ASL or ASC DP	ASC DP	Oxidation CH			Bio	CA
0492A	1944	1944	1214	690	40,000	58	I	N	APS	N	R	(2)	Y	I	N	Ret	64	0	0		
0513A	1929	1922	450	400	Unk	Unk	I	N	APS	N	C	(2)	Y	ASL	N	In	Unk	0	Unk		
0584B	1953	1951	2590	2500	Unk	Unk	I	840	APS	Y	C	(2)	Y	I	Y	In	0	Unk	Unk		
0594B	1970	1970	2900	2700	Unk	Unk	I	53	APS	Y	C	(2)	Y	I	Y	In	0	Unk	Unk		
0584C	Pre- 1921	1946	1979	2640	(2590)	380,700	147	I	42	APS	N	C	(2)	Y	ASL	N	In	199	0	0	
0584F	1973	1973	(3680)	(3000)	630,000	(212)	I	D	APS	H	C	(2)(3)	Y	ASC	N	In	(237)	0	0		
0584F	1923	1947	1979	(4500)	(4066)	775,000	(191)	I	28	APS	I	C	(2)	Y	ASC	I	Ret	(112)	0	(130)	
0636A	1906	1916	650	590	150,500	255	N	N	N	N	N	N	N	N	N	No Trt	0	136	119		
0684A	1950	1950	2970	2735	244,000	89	I	N	APS	N	R	(2)	N	N	N	No Trt	0	0	89		
0684B	1923	1948	1852	1279	311,700	259	I	N	APS	N	C	(2)	I	I	N	In	113	0	146		
0684D	1927	1955	576	500	119,500	239	I	N	APS	H	C	(2)	I	I	N	Ret	0	0	0		
0684F	1917	1947	(2764)	(2049)	(277,000)	(135)	I	N	APS	Y	R	(2)	Y	ASC	Y	CAG Ret	(62)	0	(73)		
0684F	1952	1952	(1954)	(1286)	(157,000)	(122)	I	N	APS	Y	R	(2)	Y	ASC	Y	CAG Ret	(59)	0	(63)		
0684H	1943	1943	1369	1200	566,800	436	I	N	APS	Y	C	(2)	Y	ASL	Y	In	0	452	0		
0684I	1918	1947	2372	1785	371,300	208	I	N	APS	N	C	(2)	Y	ASL	N	Ret	218	0	0		
0684J	1914	1952	1066	560	167,400	299	I	N	APS	N	C	(2)	Y	ASL	N	Ret	309	0	0		
0724F	1920	1920	650	560	318,080	568	I	N	APS	Y	C	(2)	Y	ASL	Y	Ret	584	0	0		
0727A	1929	1950	2025	1610	302,000	219	I	20	APS	Y	C	(2)	Y	ASL	Y	CAG Ret	144	0	82		
0810	1917	1962	*	*	*	*	I	2	APR	Y	C	(2)	Y	N	Y	Ret	*	*	*		
0836A	1918	1948	20780	16,342	2,500,000	153	I	25	APD(6)Y	Y	R	(2)(3)	Y	ASL	Y	Ret	281	0	0		
0836F	1952	1952	3000	3000	270,000	90	I	N	APS	Y	C	(2)	Y	ASL	Y	In	50	0	52		
0836H	1917	1953	4468	4319	450,000	104	I	N	APS	N	C	(2)	I	I	I	Ret	0	0	109		
0860A	1915	1950	1580	1262	339,500	269	I	N	APS	N	N	(2)	Y	N	N	Ret	166	0	103		
0860B	1911	1949	11960	9750	1,512,000	155	I	N	APS	H	C	(2)	N	N	N	In	0	19	136		
0864A	1944	1944	(3558)	(3520)	(702,700)	(200)	I	N	APS	N	R	(2)	Y	ASL	I	In	0	0	(208)		
0868A	1912	1958	1979	(6866)	(5930)	576,000	(97)	I	N	APS	N	C	(2)	Y	ASL	Y	In	(146)	0	0	
0920B	1942	1953	1956	(1200)	(1020)	67,300	(66)	I	N	APS	Y	C	(2)	Y	ASL	Y	Ret	(78)	0	0	
0920F	1917	1945	5205	4310	559,000	132	I	N	APS	Y	C	(2)	Y	ASC	I	Ret	142	0	0		
0946A	1919	1968	1000	700	238,000	340	I	N	APS	N	C	(2)	N	N	N	No Trt	0	340	0		
0948A	1916	1954	1980	3483	469,440	135	I	N	APS	Y	C	(2)	I	I	Y	In	0	0	135		
0948C	1919	1955	1961	4000	391,700	115	I	N	APS	Y	C	(2)	Y	ASL	Y	In	0	0	123	0	

-1- Plant 1	APT: Ammonia Product Type:	DP: Dephenolizer	Discharge Mode - Other
-2- Plant 2	APS: Ammonium Sulfate	Y: Yes	DW: Deep Well Disposal
-3- Plant 3	APH: Ammonium Hydroxide	N: No	PH: Preheater Make-up Water
-4- Plant 4	APP: Ammonium Phosphate	I: Inactive	CCI: Controlled Combustion Incinerator
(D) Brown's Island	APD: Other (See Footnotes)	CH: Chemical Oxidation	ES: Evaporate on Sleg
(N) Mainland	N: No Ammonium Product	CLA: Alkaline Chlorination	H: Hauled to Treatment at Plant 0624F
(R) Rosedale	ASL or ASC: Fixed Ammonia Still	CLB: Breakpoint Chlorination	L: Impoundment Lagoon
(F) Franklin	ASL: Using Lime	O: Other (See Footnotes)	
TPD: Tons per day	ASC: Using Caustic	BIO: Biological Oxidation	
GPD: Gallons per day	I: Inactive	ROA 1: Single Stage	
GPT: Gallons per ton	N: None	ROA 2: Multi-Stage	(1) Process Wastewaters Only
NH <sub>3</sub> : Ammonia Recovery Type	POH: Phenol Recovery:	CA: Carbon Adsorption (Granular)	(2) Naphthalene
1: Semidirect	Y: Yes N: No	In: Initial Installation of	(3) Sulfur
2: Indirect	I: Inactive	Treatment Plant	(4) Ceased Operation Permanently
N: No NH <sub>3</sub> Recovery	BTX Recovery:	Ret: Retrofit Installation	(5) Oxidation Tower
DS: Desulfurizer Type:	C: Crude	of Treatment Plant	(6) Anhydrous Ammonia
D: Dry	R: Refined	Unk: Unknown	(7) Plant uses Two Fixed Stills
N: No Desulfurizer	N: None	*: Plant requested confidential	( ) Production and flow data
Number: Gallons of	OTH: Other Product Recovered	treatment of data.	within parenthesis obtained
Wastewater	(See Footnotes)		from D-DCP responses or
Per Ton of Coke	ASF: Free Ammonia Still		plant visits.
	Y: Yes N: No		
	I: Inactive		

Note: For definitions of other operational and control and treatment codes, refer to Table VII-1.